

# A Dual-polarized, Dual-frequency, Corrugated Feed Horn for SMAP

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**Abstract**— SMAP will be the first Earth science mission to use a deployable 6m mesh reflector for both radar and radiometric measurements from low Earth orbit. The instrument antenna will spin at about 14 rpm, making the design of both reflector and feed more challenging. While the performance requirements imposed by the radar instrument are relatively benign, those pertinent to the radiometer are more difficult to meet. Extreme care was necessary in designing the feed, especially from a performance stability perspective. Thermal variations due to the spacecraft going in and out of eclipse during orbit and direct solar radiation into the horn are just two of the challenges faced during the design phase. In this paper, the basic concepts behind the design of SMAP's feed will be discussed. Each component of the feed will be analyzed in detail with particular emphasis on its impact on major RF requirements. Overall performance of the feed will also be discussed.

## I. INTRODUCTION

The Soil Moisture Active and Passive (SMAP) Mission [1] will provide a global mapping of soil moisture and freeze/thaw state with unprecedented accuracy, resolution, and coverage. SMAP science objectives are to acquire space-based measurements over a three-year period. The SMAP instrument architecture includes both an L-band radar and an L-band radiometer that share a single feed-horn and deployable parabolic mesh reflector. The reflector is offset from nadir and rotates about the nadir axis at approximately 14.6 rpm, providing a conically scanning antenna beam with a surface incidence angle of approximately  $40^\circ$ . The reflector has a diameter of 6 m, providing a radiometer footprint at the surface of 40 km spatial resolution. The real-aperture radar footprint spatial resolution is 30 km, defined by the two-way antenna beamwidth. The single feed-horn operates in both V and H polarizations and its design has been optimized for physical dimensions and performance at the same time.

In the next section we will provide a brief description of the major components of the feed assembly and where they are mounted on the observatory. For each component we will cover the major design trades and the reasons behind their final shape and form. The basic design concepts will then be presented in Section III.

## II. FEED ASSEMBLY COMPONENTS

The feed assembly is mounted on the spinning platform of the observatory and spins with the reflector. The radiometer electronics and other electronic components also spin with the feed. The radar electronics, because of the large radiator surface required for heat dissipation, are located in the bus and V and H polarization channels are connected to the radar through a dual channel rotary joint.

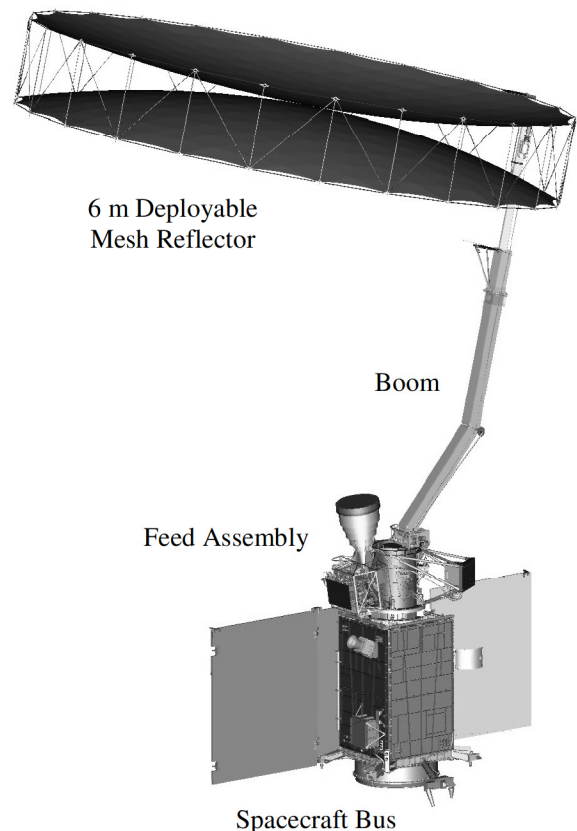


Figure 1. CAD model of the SMAP observatory.

Figure 1 shows the CAD model of the SMAP observatory. From top to bottom, the deployable mesh reflector is attached to a graphite composite boom which in turn is attached to the spun platform assembly (SPA) composed of the feed horn and the radiometer electronics boxes. All of these components spin at a nominal rate of 14.6 rpm during operations. The solar panels, the square bus and all the other components below the SPA do not spin.

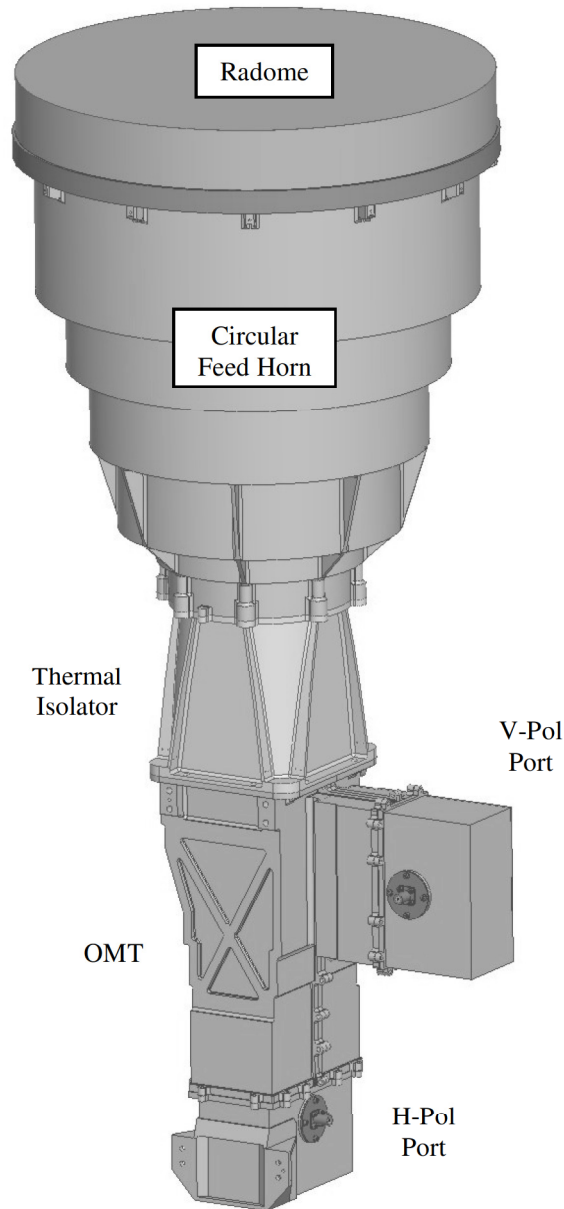


Figure 2. SMAP Feed Assembly

Figure 2 shows the basic blocks of the Feed Assembly. A radome made of Expanded Polystyrene (EPS) is attached to the aperture with an L-shaped ring made of Ultem-1000. The circular feed horn made with four corrugations is connected to the thermal isolator made of titanium. The Ortho-Mode

Transducer (OMT) is then connected to the two ports for V and H polarizations. The horn and the isolator, as can be seen from Fig. 1, are exposed to the environment. Despite the fact that they are covered in Multi-Layer Insulation (MLI) they experience large swings in temperature during operations, especially during eclipses. The OMT and the two ports instead are surrounded by a cocoon that includes also part of the radiometer electronics, keeping the bottom end of the feed assembly much more protected and thermally stable.

### III. BASIC DESIGN CONCEPTS

The radome was introduced to improve the thermal stability of the entire feed assembly since during certain seasons the sun shines directly into the horn aperture and affects the thermal stability of the entire feed assembly. The horn design was constrained between the cut-off frequency of the first mode ( $1.115 \text{ GHz}$  for the  $TE_{11}$ ) and that of the third one ( $1.457 \text{ GHz}$  for the  $TM_{01}$ ) which tends to slightly steer the main beam. The horn input diameter at the interface with the isolator was selected based on the above constraints and tuning steps on either side of the interface were designed to obtain the largest possible bandwidth. Considering that the instrument needs to perform between  $1.21 \text{ GHz}$  and  $1.43 \text{ GHz}$ , there was very little margin left in the design. The Thermal Isolator also performs as square-to-circular waveguide transition and is made of three steps. The OMT was designed with the intent to keep the excitation of the third  $TM_{01}$  mode to a minimum by “stepping” the geometry from the H-Port on both sides rather than on one side only, consequently achieving a better overall symmetry. Last but not least, the waveguide-to-coax adapters (WCA) were designed in WR-650 waveguide in order to enable measurements and testing with a standard calibration kit. The two adapters are “electrically” the same, only the external housing differs from one another for mounting purposes and the internal probes were tuned in conjunction with two irises located at the interfaces with the OMT. This allowed for a very short and compact design for this wavelength. Instrument balancing and mass properties consideration limited the maximum length available for the feed assembly and the design was shortened by a few centimeters with the introduction of the two irises. The overall performance meets all the requirements with good margins. Thermal and fabrication tolerance analyses were also performed in order to verify the compliance to requirements under all operating conditions.

### ACKNOWLEDGEMENT

This work was performed at Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. The SMAP mission has not been formally approved by NASA. The decision to proceed with the mission will not occur until the completion of the National Environmental Policy Act (NEPA) process. Material in this document related to SMAP is for information purposes only.

### REFERENCES

- [1] Official SMAP website “<http://smap.jpl.nasa.gov/>”.